Vector network analyzer ferromagnetic resonance with field differential detection

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Ferromagnetic resonance (FMR) is the most commonly used measurement for characterizing magnetization dynamics in the microwave frequency range. To explore the frequency dependence of magnetization dynamics, a vector network analyzer ferromagnetic resonance (VNA-FMR), which can perform a broadband FMR measurement, has been used. However, the VNA-FMR measures the S-parameter that contains the FMR signal of interest under a constant bias field, thus its signal-to-noise ratio (SNR) is limited by the sensitivity fluctuation of the VNA, i.e. low frequency components of the trace noise. Another problem identified in this work is that the analysis of the measurement data taken by the VNA-FMR for estimating the Gilbert damping parameter still follows the conventional algorithm based on the spectral linewidth, which we found is not optimum for the VNA-FMR.

We have developed a new VNA-FMR and data analysis algorithm optimized for it to solve these problems. We added a modulation coil in this VNA-FMR to apply a small modulation field in addition to the bias field. The S-parameters are acquired repeatedly as the polarity of the modulation field is switched back and forth, and the results taken under the negative modulation field are subtracted from the ones taken under the positive to extract only the change of the S-parameter responding to the change of the magnetic field. Thus this data acquisition sequence differentiates the S-parameter with respect to the magnetic field, which effectively removes the non-magnetic background that fluctuates over time. We also came up with a new data analysis algorithm for the VNA-FMR. Since the VNA-FMR gives a complex S-parameter, it is possible to estimate the Gilbert damping parameter from the slope of the phase with respect to the bias field. We show that this new analysis algorithm is in fact more robust against noises than the conventional algorithm based on the spectral linewidth.

Acknowledgement: This work is supported by the JST strategic innovation promotion program, “Development of new technologies for 3-D magnetic recording architecture.”

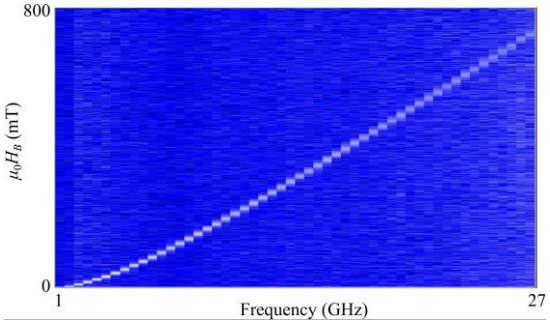

Fig. 1, FMR spectrum as a function of frequency and bias field taken by the new VNA-FMR

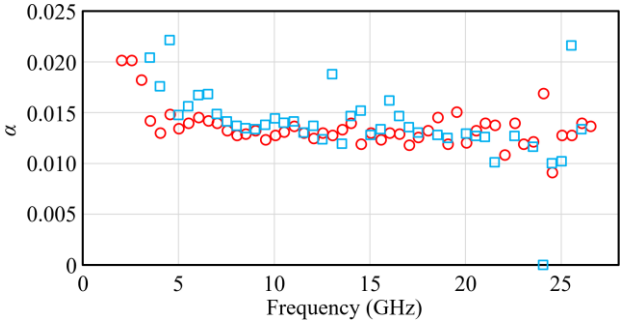

Fig. 2, Gilbert damping parameter estimated by the old (blue) and new (red) algorithms.